

Skylighting Proposals

Statewide Codes & Standards Program

Prepared for CEC Workshop May 30, 2002

Presentation by PG&E/HMG/Jon McHugh

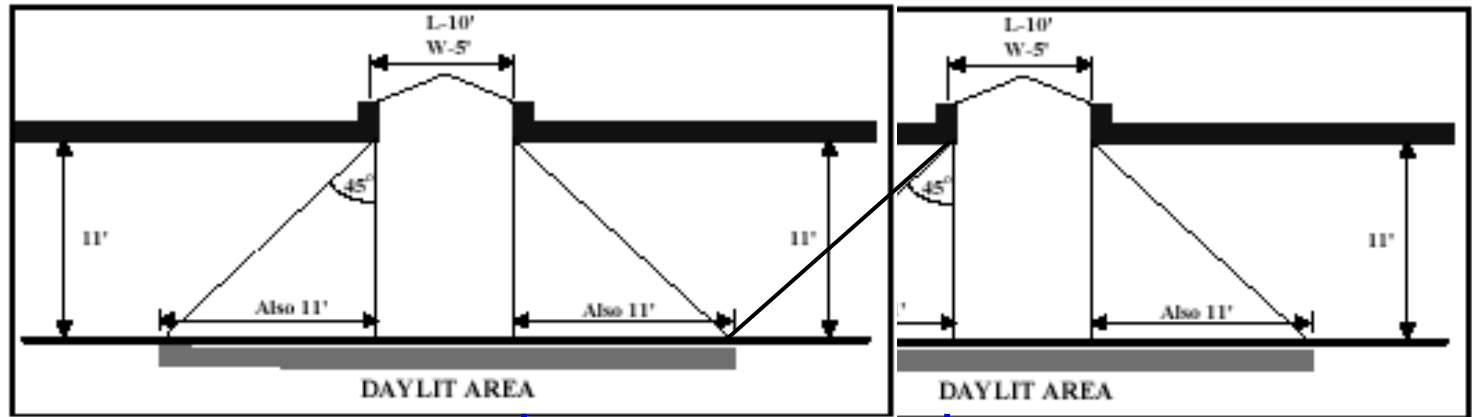
Project Manager, Steve Blanc, PG&E



Key Proposals

- Definition of Skylit Zone
- Definitions of Effective Aperture and Well Efficiency
- Requirements for Automatic Daylighting Controls
- Revised Power Adjustment Factors
- Mandatory Automatic Controls
- Skylighting as Base Case

Existing Daylit Zone Definition



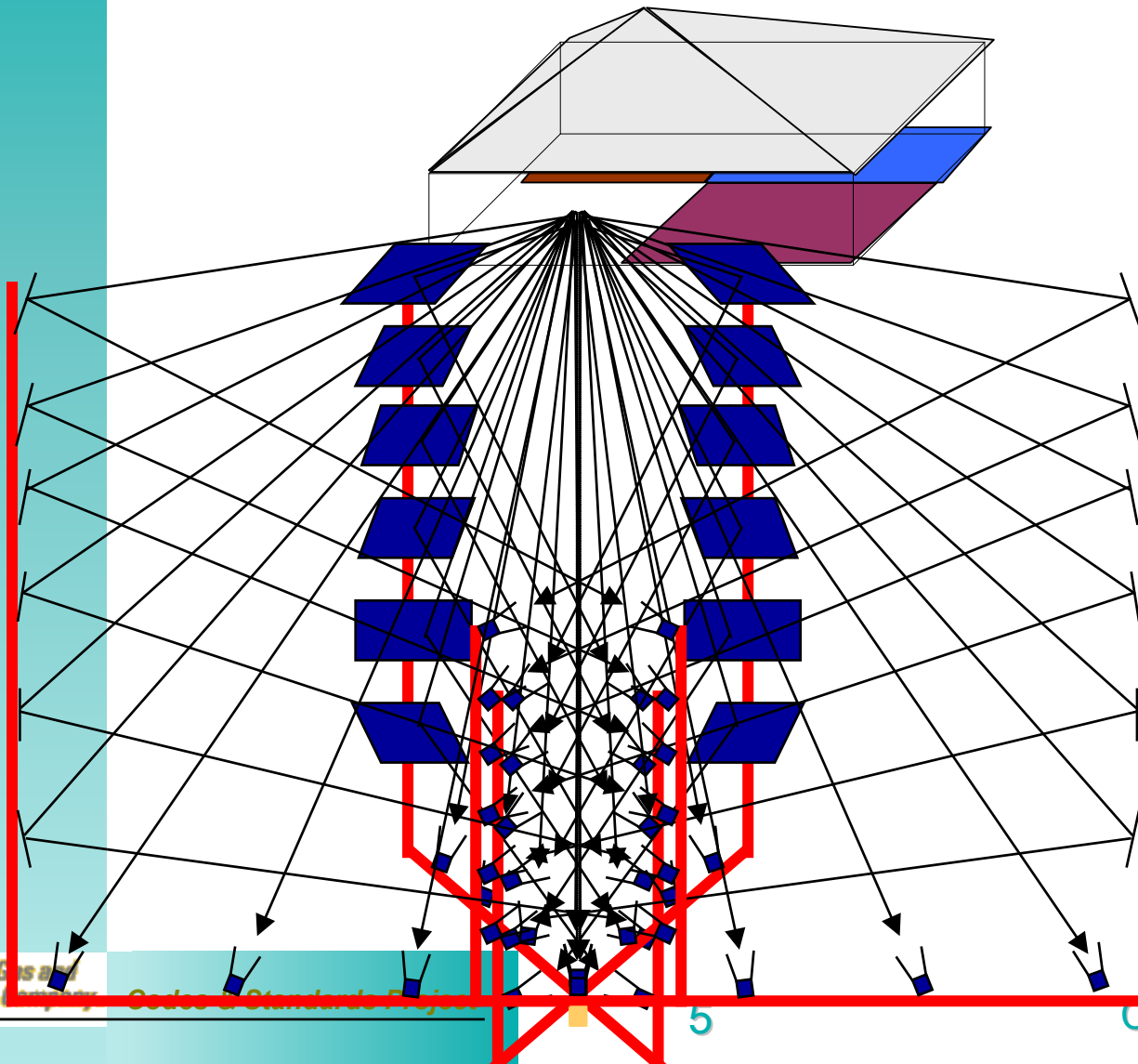
2 x Ceiling Height
Spacing Criterion = 2.0

“For areas daylit by horizontal glazing, the daylit area is the footprint of the skylight plus, in each of the lateral and longitudinal dimensions of the skylight, the lesser of the floor-to-ceiling height, the distance to the nearest 60-inch or higher opaque partition, or one half the horizontal distance to the edge of the closest skylight or vertical glazing.”

Spacing Criterion (SC)

- Simple method for evaluating spacing of luminaires for lighting uniformity
- Published by most luminaire manufacturers
- SC conservative spacing - other criteria often require closer spacing
- Skylight photometrics tested as part of NBI/CEC Public Interest Energy Research (PIER)
- SC data calculated from photometrics
- SC data for skylights not previously available

Goniophotometry



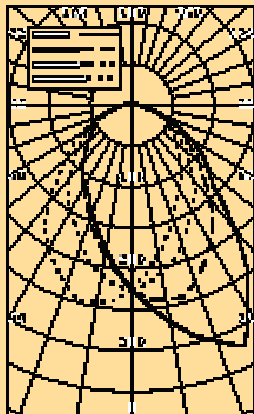
Photometric reports

Lighting Science Inc.
7810 E. Evans Rd.
Scottsdale, AZ, USA 85250

Data captured from Auto Cad Light fixture data point file

COMMISSIONER SUMMARY

ANGLE	0	75	90	99.8
0	227.0	227.0	227.0	227.0
5	247.4	229.1	221.0	202.7
90	244.8	212.7	207.5	185.7
95	250.2	217.0	207.7	169.7
20	280.0	228.2	219.5	148.1
25	224.0	212.1	200.9	129.8
30	285.3	202.9	217.5	117.6
35	244.7	172.6	222.8	106.6
40	251.8	147.1	206.5	95.1
45	220.0	122.1	191.2	79.8
50	221.0	102.6	181.1	68.6
55	189.2	87.2	171.6	58.2
60	79.0	68.1	160.0	53.6
65	84.0	52.0	140.1	48.8
70	75.7	36.0	121.5	35.9
75	70.6	18.0	96.2	17.1
80	4.8	10.7	9.5	10.1
85	0.0	1.6	2.7	3.6
90	.0	.0	.0	.0



ANGLE	90.0	225	270	315
0	227.0	227.0	227.0	227.0
5	202.8	207.0	222.7	210.6
90	181.8	187.6	221.7	216.1
95	169.2	186.6	204.9	200.2
20	172.0	179.2	207.9	214.9
25	120.0	129.9	202.1	219.7
30	124.4	118.1	189.9	201.1
35	104.3	107.0	228.9	187.1
40	91.4	91.1	207.0	187.1
45	78.2	79.6	191.1	127.2
50	64.0	69.1	87.2	107.0
55	67.6	66.6	12.2	88.8
60	88.7	81.1	50.0	59.8
65	82.0	48.0	40.1	67.8
70	75.7	22.7	32.5	35.1
75	70.6	17.1	96.9	17.9
80	70.6	10.6	90.1	10.6
85	0.0	1.0	4.0	3.7
90	.0	.0	.0	.0

COMMISSIONER SUMMARY

SPOT	WATTAGE
0-30	163
0-45	264
0-60	403
45-90	230
60-90	71
0-90	474

REVISIONS 17.6A

SC(FRONT) = 1.5 SC(BACK) = 1.0

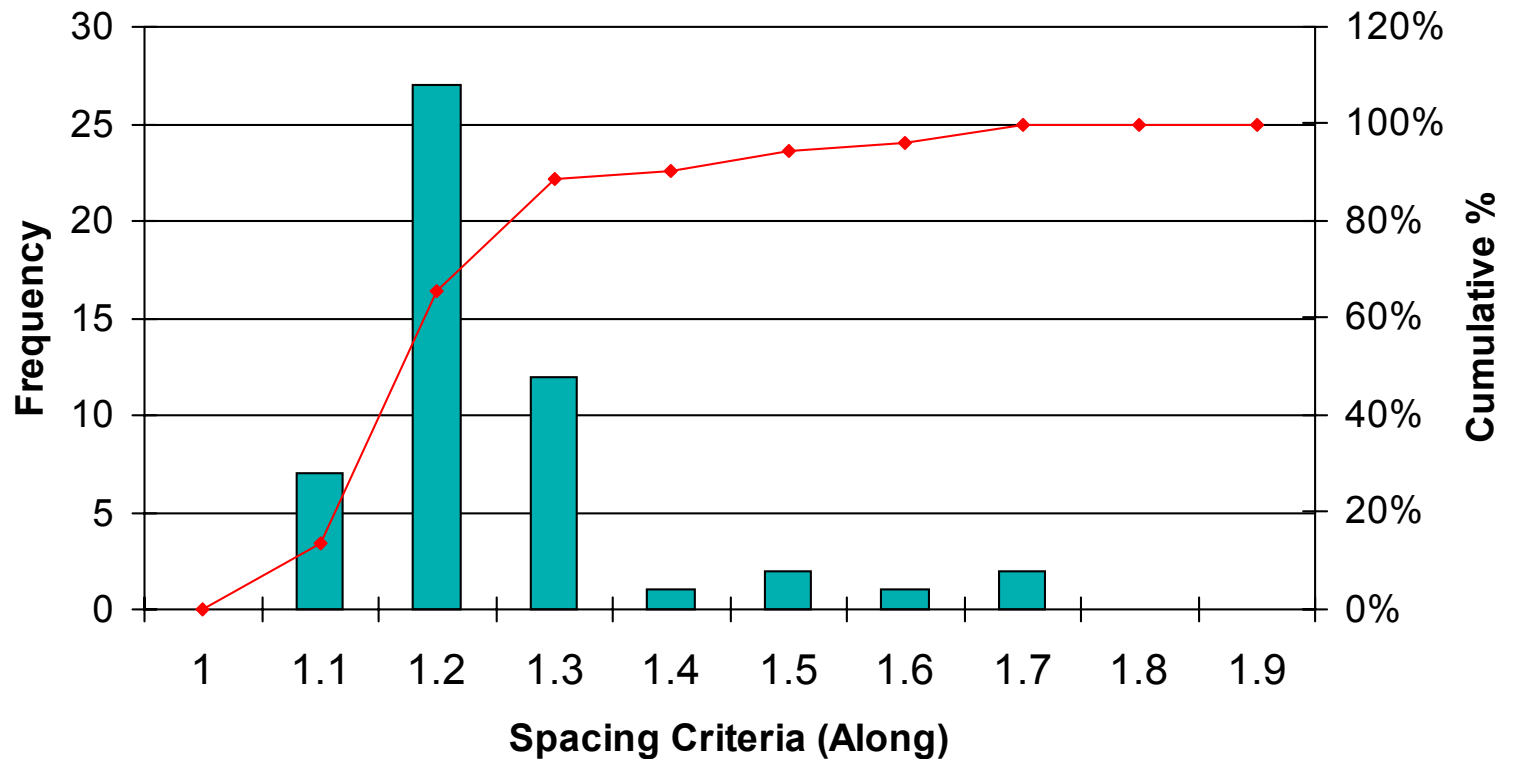
- Same specification as electric lighting
- Polar plots - shape of light distribution
- Spacing criterion
- Coefficients of Utilization

SC of White Skylights

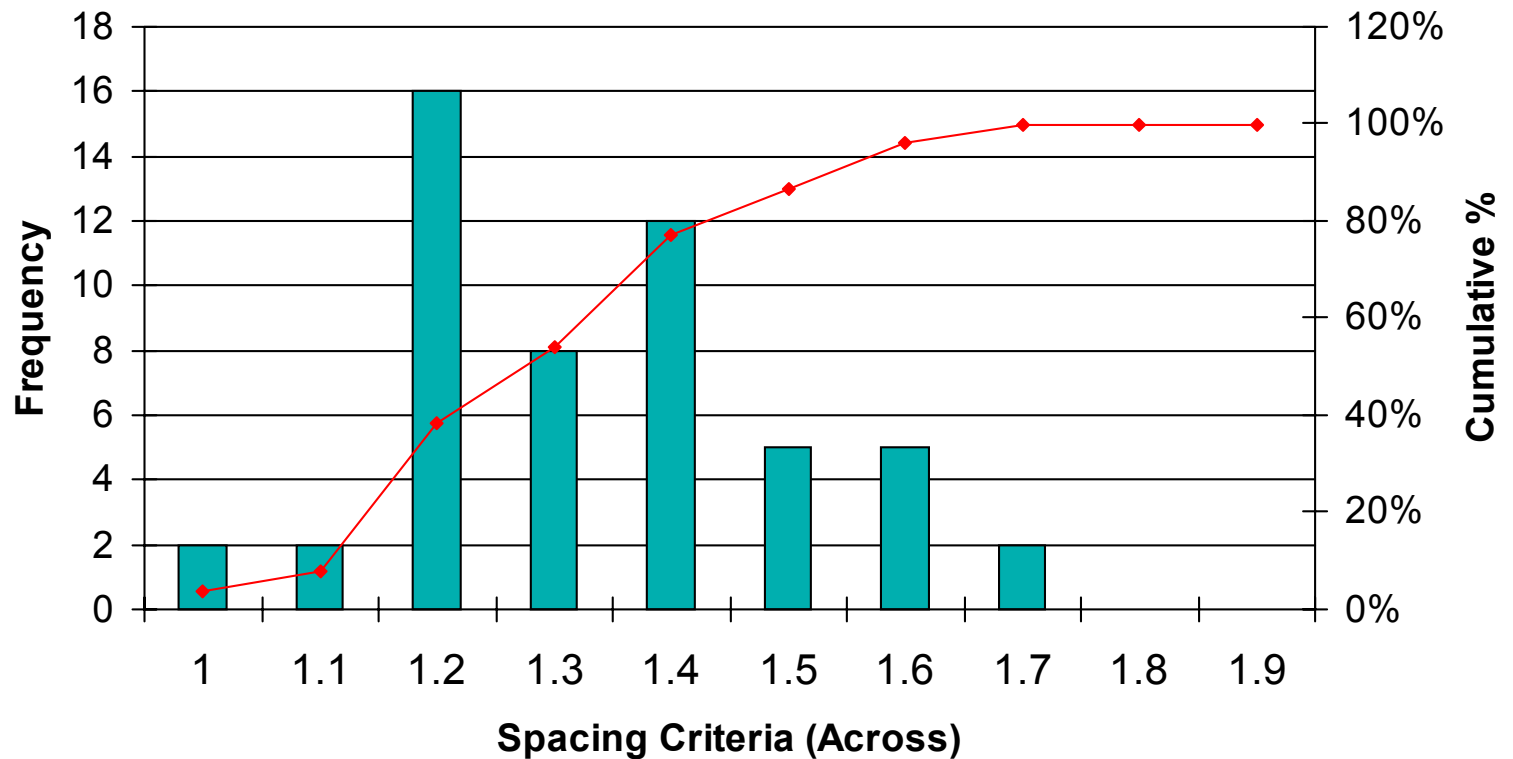
- Clear sky measurements
 - 10 - 60° solar elevation
- Very diffusing glazings, haze = 100%
- 3 skylights considered
 - Domes - white and clear over white
 - Compound parabolic - white single glazed
- 1 ft white light wells



Spacing Criterion-White Skylights



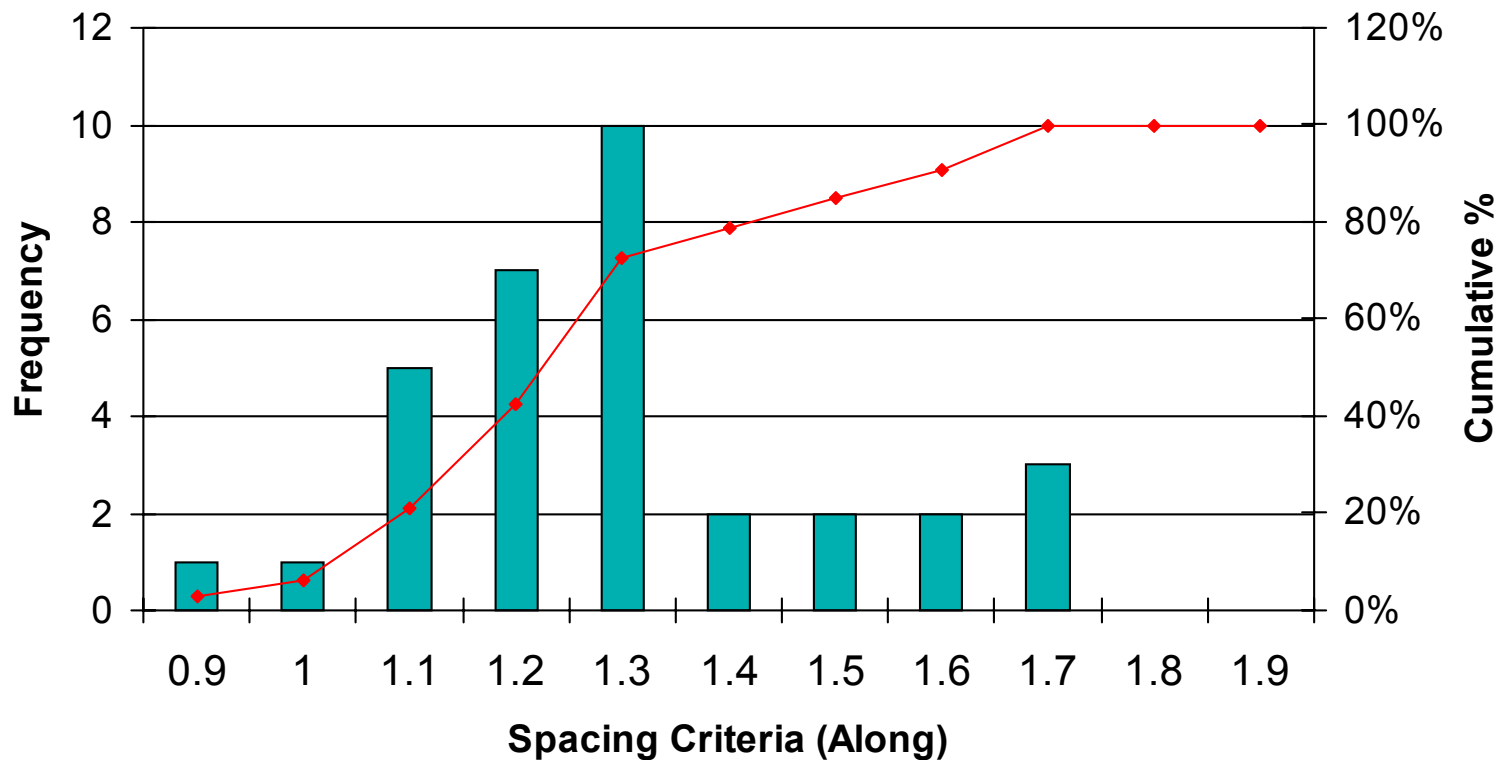
SC White Skylights (Cont.)



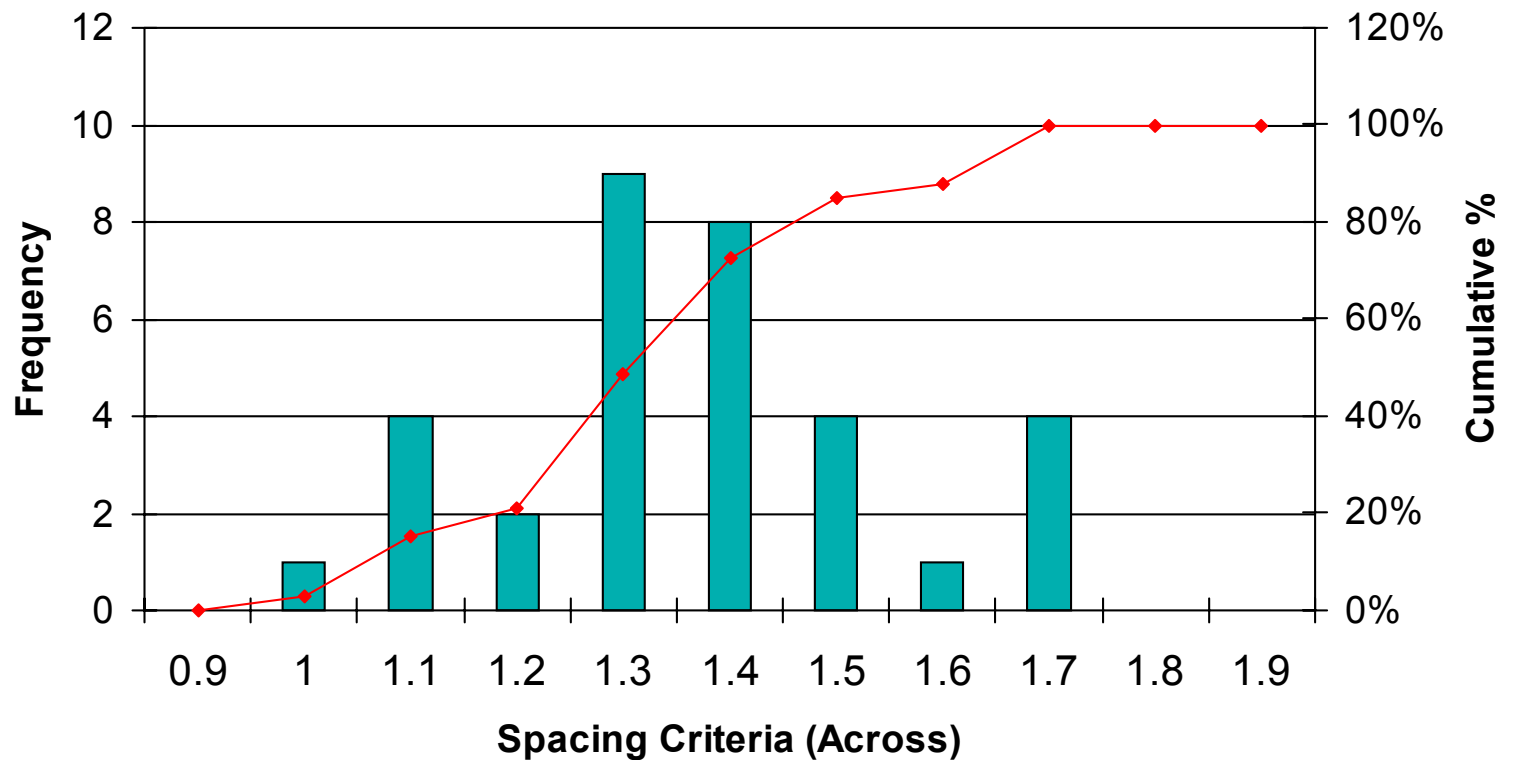
SC of Skylights with Diffusers

- Clear sky measurements
 - 10 - 60° solar elevation
- Prismatic acrylic diffuser on bottom of vertical light well
- Double flat glass skylights
 - with 6 ft white diffusing well
- Medium white acrylic skylights
 - with 6 ft and 3 ft specular (mirror like) wells

SC Skylights with Diffusers

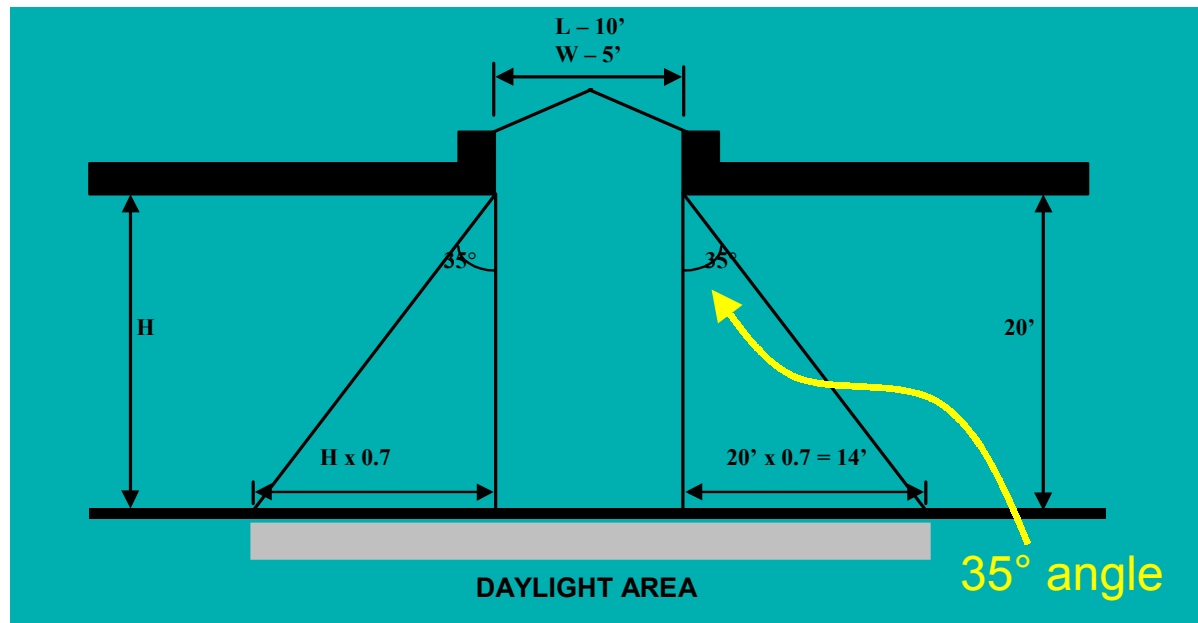


SC with Diffusers (Cont.)



Results and Recommendations

- 80% of results had $SC \leq 1.4$
- Revise daylit zone definition
 - Expand “footprint” by 70% of ceiling height



Effective Aperture and Well Efficiency

- Effective Aperture - % of light on roof that makes it through the skylight and light well

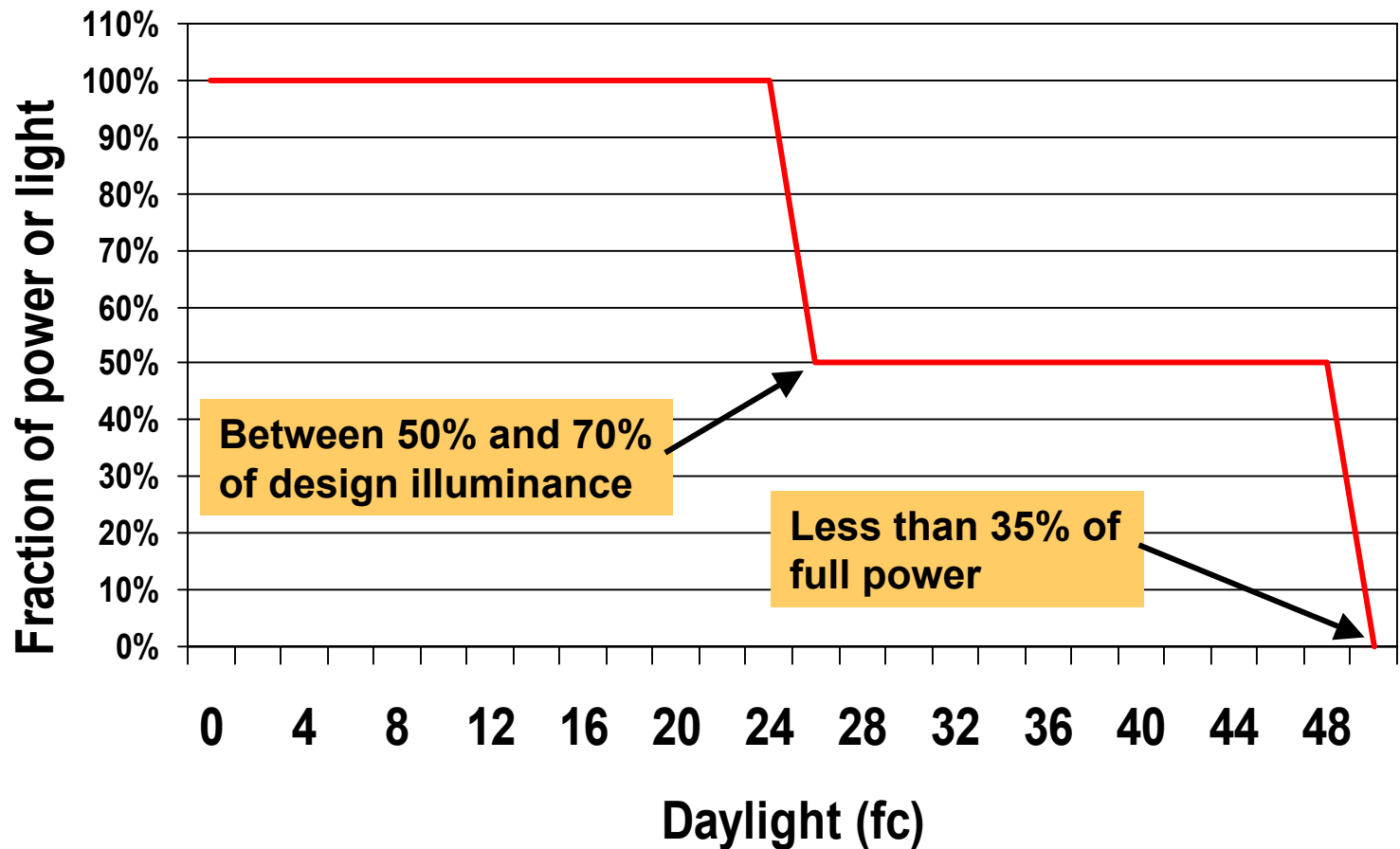
$$EA = \frac{\text{Skylight Area} \times \text{Transmittance} \times \text{Well Efficiency}}{\text{Daylit Area}}$$

- Well efficiency calculated from IESNA current method of well cavity ratio
- Skylight area defined by rough opening

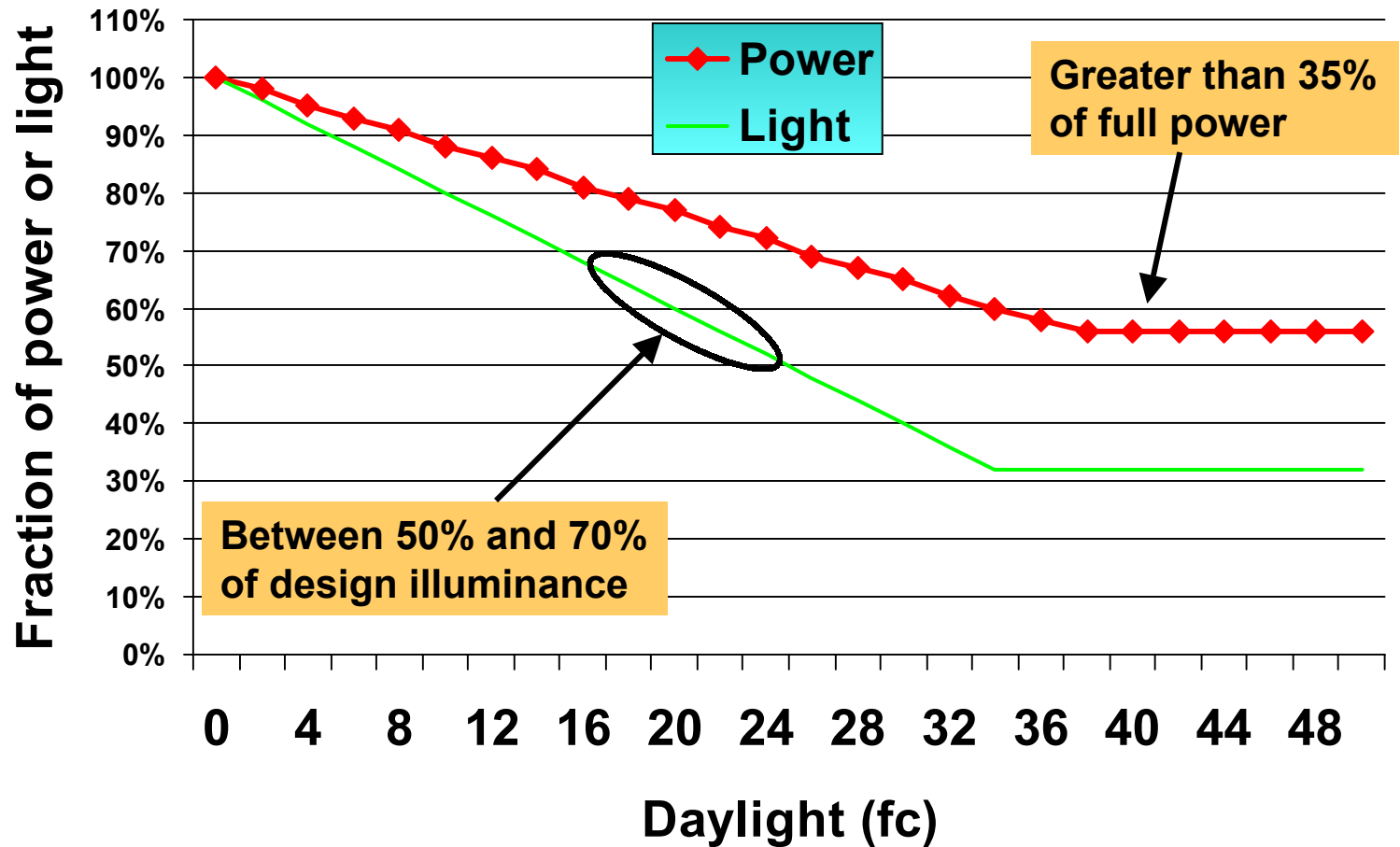
Requirements for Automatic Daylighting Controls

- Multi-level control required
 - substantially more savings than one level
 - less distracting
- Multi-level definition
 - at least one control step that is between 50% and 70% of design illuminance
 - controlled electric lighting shall consume less than 35% of rated power at minimum light output

Two level plus off control



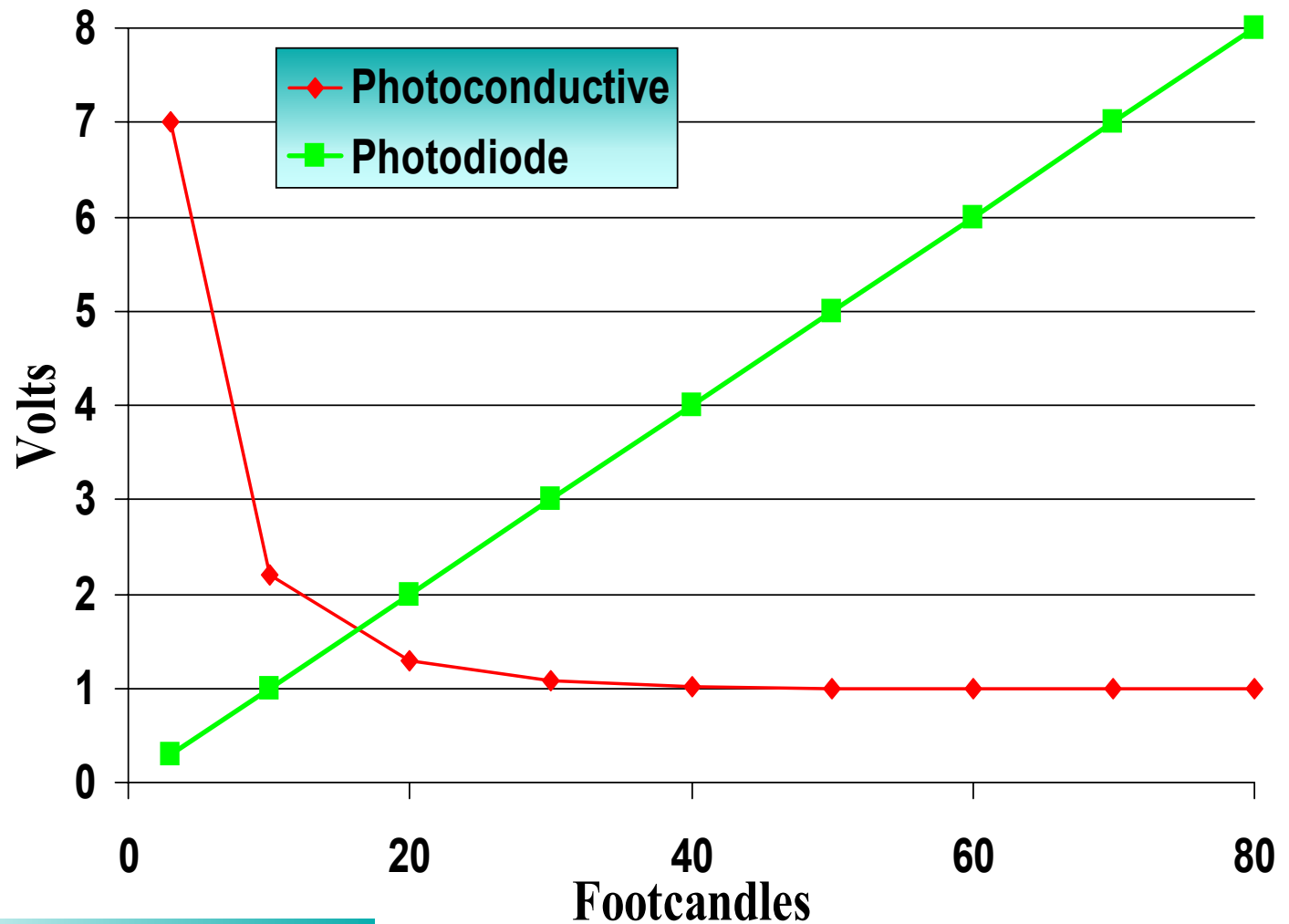
Metal Halide Dimming



Requirements for Automatic Daylighting Controls (continued)

- Indicator light on switching controls
- Time delay overridden (< 5 sec) for calibration
- light sensor - linear response to within 5%
- light sensor shall be separate from the control device where calibrations adjustments are made

Photosensor Sensitivity



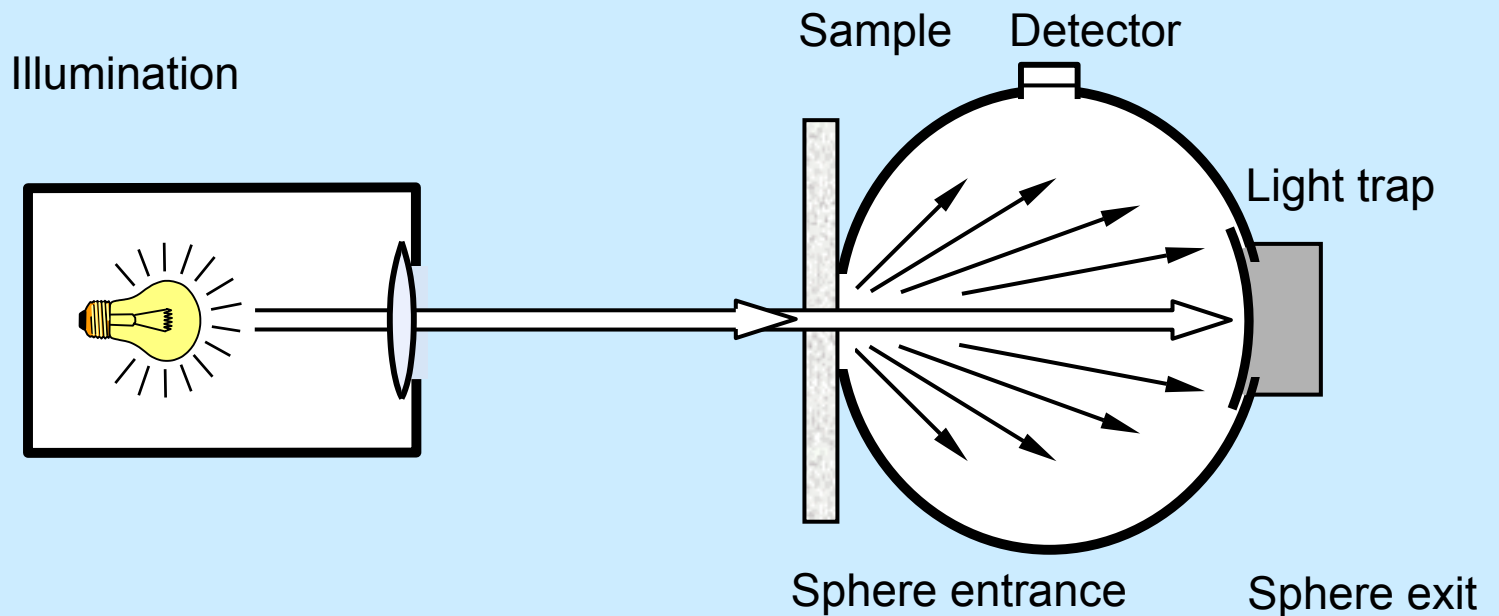
Requirements for Automatic Daylighting Controls (continued)

- calibration adjustments to the lighting control device shall be readily accessible to authorized personnel
- setpoint control have an indicator so that settings can be easily distinguished to within 10% of full scale adjustment

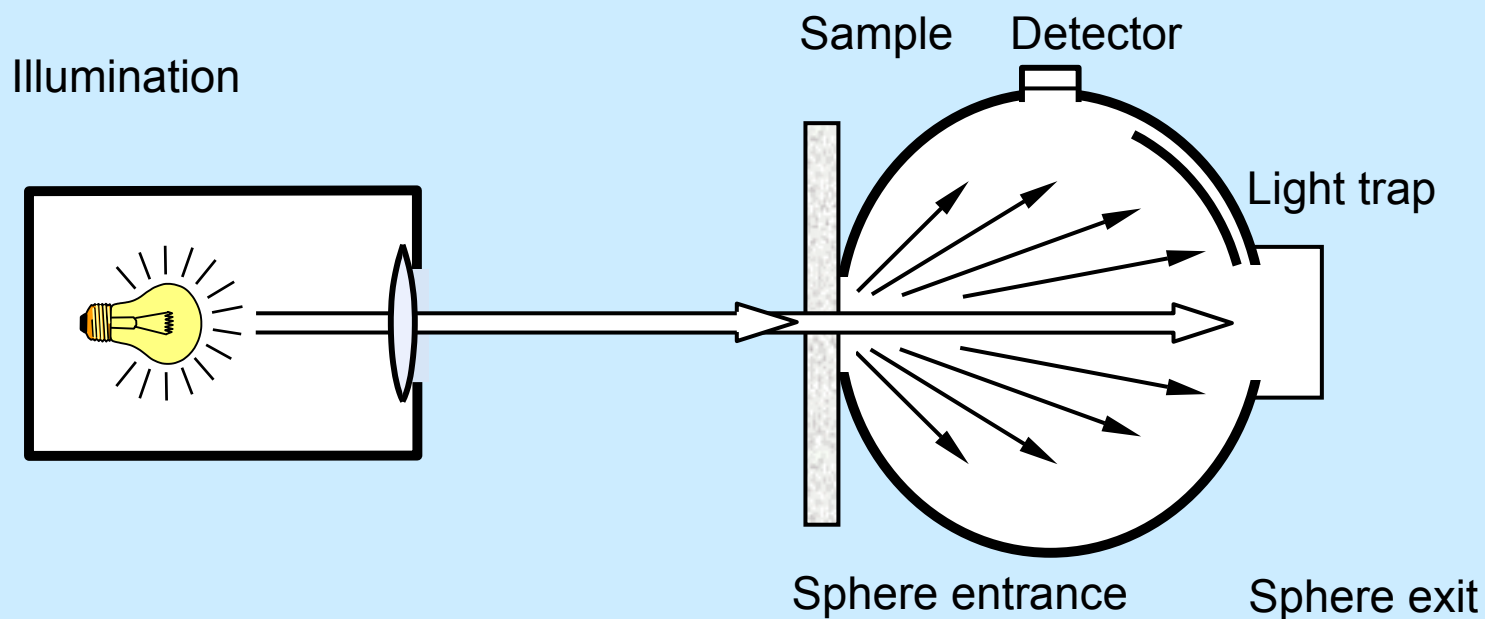
PIER Testing of Glazing Properties

- Repeatable metric of glazing properties
- Transmittance and diffusion (haze)
- Contracted with DSET Labs, Phoenix, AZ
- Testing according ASTM D1003-00
- BYK Gardener Haze Gard Cat #4725
- Inexpensive test - less than \$10/sample

Measurement of Total Transmittance



Measurement of Diffuse Transmittance



$$\text{Haze} = \frac{T_{\text{dif}}}{T_{\text{T}}} \cdot 100 \%$$

Glazing Test Results

Description	Tvis	Haze
White Acrylic	62.6%	100.0%
Clear Acrylic	94.9%	0.3%
Bronze Acrylic	28.2%	1.5%
White PET	48.8%	100.0%
Thick Prismatic	84.8%	98.1%
Twinwall Polycarb	83.6%	33.2%
Fiberglass Assembly	29.2%	92.2%
Fiberglass Sheet	79.1%	69.0%
Prismatic Diffuser	85.8%	97.2%

Conclusions from Glazing Testing

- Single glazed fiberglass, twinwall polycarbonate, clear and bronze skylights are glarey unless shielded
- All other materials have haze values above 90%.
- Skylight manufacturers trying to increase diffusion from materials with haze > 90%
- Haze requirement: greater than 90%

Mandatory Controls in Skylit Zone

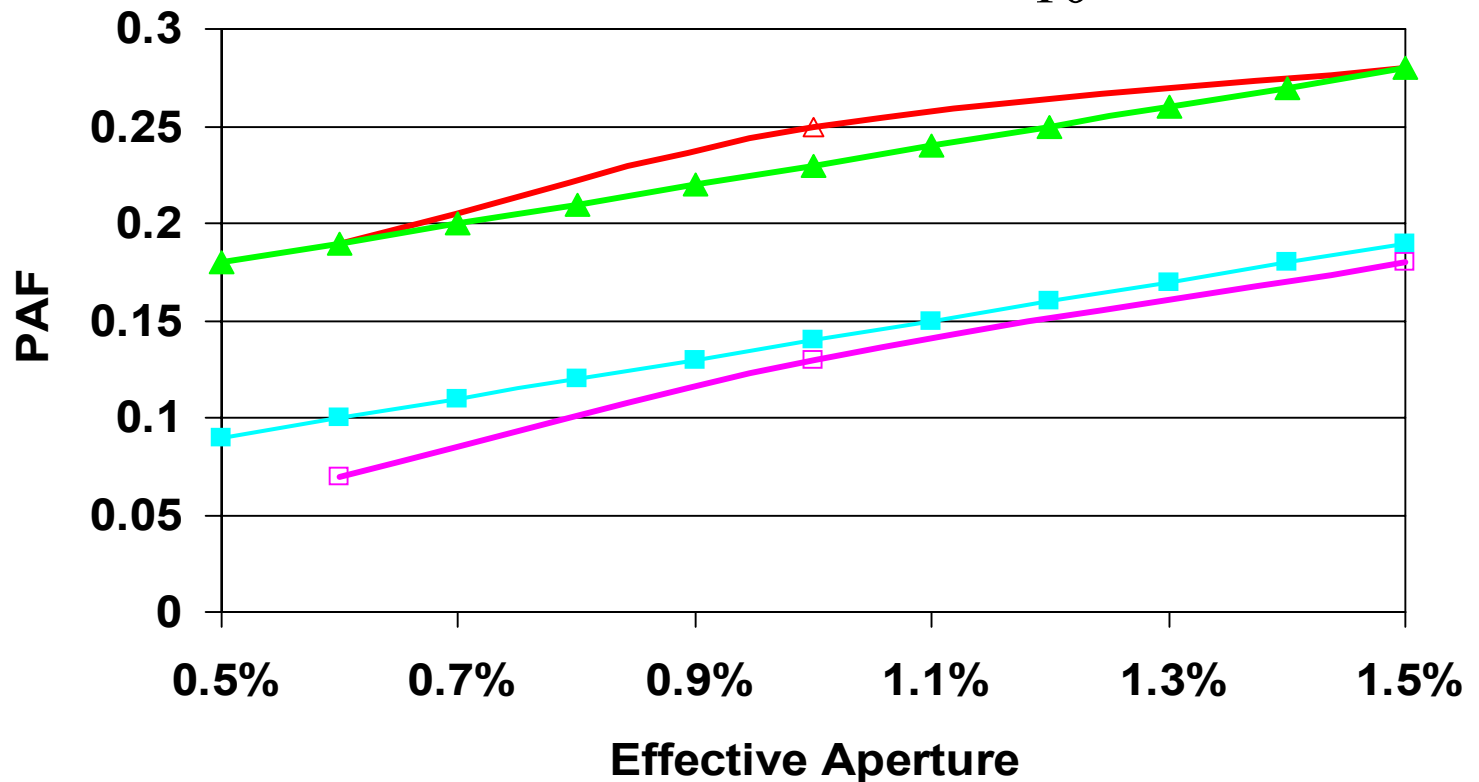
- Skylights don't save energy if lights are on.
- Automatic controls needed to save energy.
- Multi-level automatic daylighting controls typically cost < \$2,000 per system.
- LCC Savings = \$1.50/SF to \$4.00/SF
 - 0.7 W/SF and up, EA > 0.6%
- Clearly cost-effective in enclosed spaces > 2,500 SF

Mandatory controls in skylit zone

- Not many practitioners with great experience with daylighting controls
 - Allow astronomical time clock to provide control
- Give PAF incentive for use of daylighting controls
 - 1/2 of calculated savings as compared to no control
 - Available only for diffusing skylights (haze greater than 90%)

PAF's for Automatic Multi-level Daylighting Controls

$$\text{PAF} = 10 \times \text{Effective Aperture} - \frac{\text{Lighting Power Density}}{10} + 0.2$$



—△— LPD = 0.7 —□— LPD = 1.6 —▲— Calc LPD = 0.7 —■— Calc LPD = 1.6

Prescriptive Requirement for Skylights

- Skylights are a cost-effective method of saving energy
 - Documented in benefit/cost ratio tables
- 22% of statewide savings from utility Nonresidential New Construction programs come from skylights and controls
- Should be requirement of Title 24 standards for appropriate buildings

Prescriptive Skylight Requirement

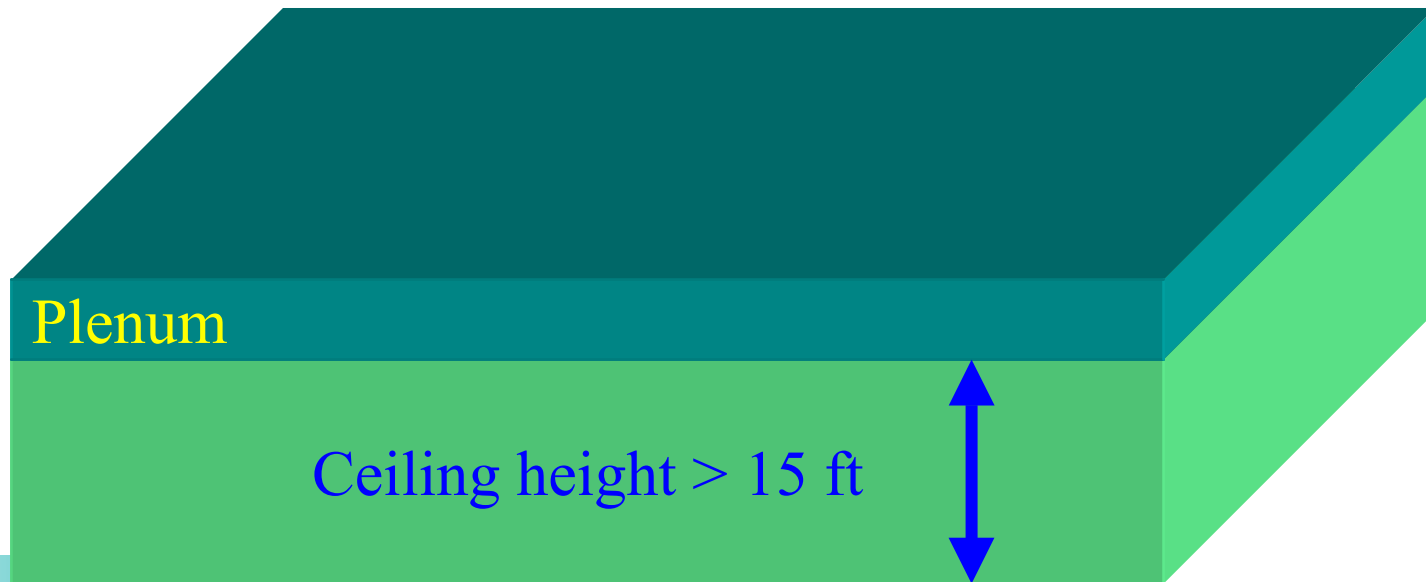
Directly under a roof

Low rise

Greater than 25,000 SF

“Enclosed space” > 25,000 SF

General Lighting > 0.5 W/SF



Prescriptive Requirement for Skylights

- 1/2 of floor area in daylit zone
- skylights with haze greater than 90%
- Min skylight area lesser of SFR and EA requirements
 - 3% SFR when $0.5 \text{ W/SF} < \text{LPD} < 1 \text{ W/SF}$
 - 4% SFR when $\text{LPD} \geq 1 \text{ W/SF}$
- Double glazed skylights except unconditioned spaces